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THE ASSESSMENT OF FLOW TEMPERATURE AND COATING LAYER ON TABS PERFORMANCE

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Abstract: *One of the newest heating and cooling system developed world wide is Thermal Activated Building System. The efficiency of the radiant surfaces, especially the TABS systems is influenced by the temperature variation over their surface. This is being influenced basically by the flow temperature and the coating layer. This study through laboratory simulation and experimental measurements analyses the influence of these two factors on the functional performances of TABS.*

Key words: *TABS, assessment of flow temperature, coating layer.*

1. Introduction

The buildings are one of the major energy consumers and are responsible for a significant amount of greenhouse gas emissions, which is, as is well known, responsible for climate change. From the the total amount of energy used in buildings, the thermal energy has the highest influence, which is predominantly produced by burning fossil fuels, which leads to significant emissions of carbon dioxide (CO_2) into the environment. The main methods of reducing greenhouse gases resulting from the process of producing thermal energy used in buildings is represented by increasing the thermal insulation of buildings and use of renewable energy sources. The growing interest, throughout the world, in the concept of use for heating/cooling in indoor spaces renewable energy led to the use of low temperature heat sources such as soil, ground water, water from lakes etc. The most common method of extracting heat from these sources is the use of heat pumps witch operate with high efficiency, It is necessary that the temperature difference between the energy source and heating flow to be minimal.

The main method to ensure thermal comfort in buildings in the tertiary sector, but not only, is to use complex ventilation and air conditioning, systems, which are usually associated with high primary energy consumption. This method has seen a rapid spread in the second half of the last century, when energy prices were very low, and now with the constant increase in energy price, this solution has become an irrational concept. [5].

Due to thermal discomfort, sick-building syndrome and excessive energy consumption, the need to replace all or part of these systems and to develop new

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concepts facilities for space heating and cooling for buildings, emerged.

Currently, the heating/cooling systems rich close to the new trend (lowering energy consumption), use of renewable energy. Increase in thermal comfort can be achieved by using low temperature radiant systems combined with ventilation systems that provide only the minimum flow of fresh air to ensure the physiological comfort [2].

Today, the trend for the residential and tertiary buildings is to use better insulation, better and lon glife materials for the pipeline (eg. PEXa) , improved system controls, and wider use of renewable energy sources. All of these led to a widespread use of radiant surfaces for thermal comfort, both during heating and cooling season.

According to the REHVA guideline [1].,-low temperature heating and high temperature cooling, radiant surfaces were divided into three categories, as shown in Figure 1:

1. Radiant cooling panels-RCP
2. Water-based embedded surface cooling systems-ESCS
3. Thermally activated building systems-TABS

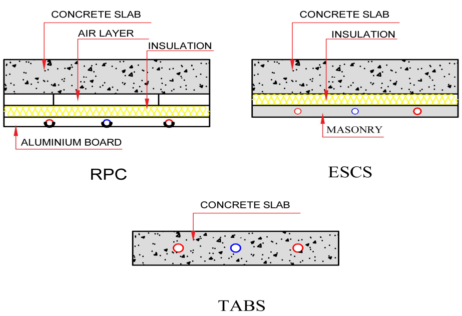

Fig. 1. *Radiant surfaces types*

2. TABS

The envelope elements such as walls, floors, ceilings can be activated by using of electric resistance, air or hydronic circuits. TABS are designed to integrate as part of the building structure and in its overall energy strategy.

The modern concept of thermally activating the building mass was conducted for the first time by Swiss engineer Robert Meierhans, which together with architect Peter Zumthor developed two successful projects, namely: Vals thermal baths in Switzerland (1996) (Meierhans and Olesen, 1999) and Bregenz Kunsthaus in Bregenz , Austria (1997) [6] and [7].

TABS are massive systems with high thermal capacity, having in this case a slow dynamic response to changes in cooling or heating loads. This feature, significantly distinguishes them from other radiant systems used to ensure thermal comfort in buildings.

During dynamic operation of TABS, there are three distinct phases, namely: / disposal/receiving heat from the hydronic circuit, storage and disposal/receiving heat to the environment. Receiving/disposal/ heat from the hydronic circuit is achieved by pumping the flow through the pipeline system embedded in the construction elements, which is a process that can be controlled by means of temperature and mass flow of heat.

The main purpose of this control is that the TABS to accumulate enough energy to future operating conditions.

Thermal storage is achieved by thermally activating the building element. Because of its high thermal massiveness, these systems will not only have a direct effect of heating/cooling, but will have the ability to reduce the maximum thermal load and transfer some of this during the vacancy of the building.

The heat transfer process of TABS from the environment is different from other air conditioning systems and is done both by convection and radiation.

3. Simulation

3.1. Simulation requirements

To highlight the influence of the coating of the radiant surface and flow temperature on the functional performance of TABS we simulated the steady state heat transfer. The simulation was done using COMSOL Multiphysics program, and Heat Transfer Module. To solve the problems of heat transfer, the program uses a mathematical structure that is based on systems of differential equations with partial derivatives. [8] [9].

TABS functional performance simulation results was analyzed on a model identical to that designed and developed in the laboratory of radiating surface of the Faculty of Civil Engineering Transilvania University of Brasov.

3.2. The influence of the coating on the functional performance of TABS

Depending on the rooms functionality, the floor coating varies from ceramic tiles to woven carpet witch directly influences the thermal properties. The type and properties of the material of which the coating of the radiating surface significantly influence both the surface temperature and the uniform heat flux.

The most common cases of floors are analyzed below (tiles, PVC carpet, and woven carpet floor) [3], their influence being directly proportional to the coefficient of thermal conductivity of the material and its thickness, as shown in the figure 2 and 3. The lower surface of TABS is most often covered only with a layer of plaster, therefore it was not modified in this study.

The influence of the topcoat on performance of the lower radiating surface is insignificant [3].

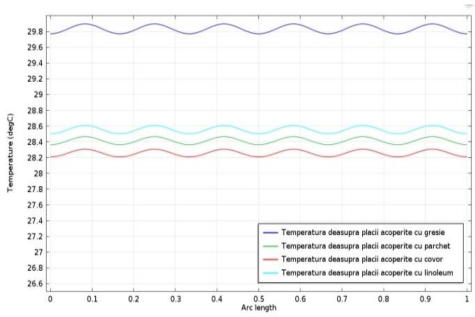

Fig. 2. *Temperature distribution for different types of the coating layer, during heating season*

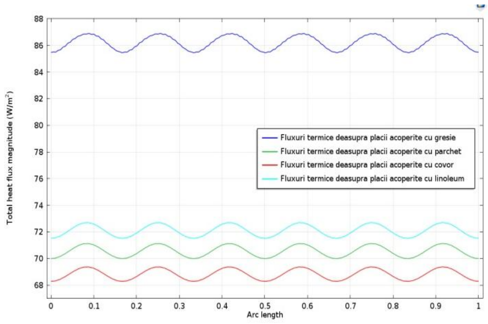

Fig. 3. *Heat flux distribution for different types of the coating layer, during heating season*

3.3. The influence of water temperature on system functional performance of TABS

Water temperature is perhaps the most important parameter influencing the thermal performance of the TABS. The increase in temperature value leads to a significant increase in the average temperature of the radiating surface. As shown in Figure 4. a temperature increase of 15°C leads to an increase in the radiating surface temperature with 6°C. At relatively low temperatures of the water flow the influence of the coating layer in the TABS temperature is insignificant. The increase in water flow temperature results in the increase of the influence of the coating layer.

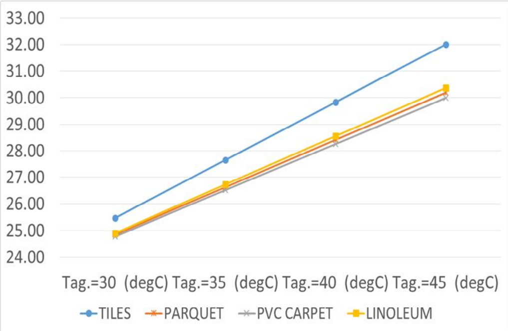

Fig. 4. *Average radiant surface temperature on the upper face of TABS system for different temperatures of the heat flow*

The increase in flow temperature from 30ºC to 45ºC to lead to an increase of about 2.8 times the heat flow delivered to the floor as you can see in the figure below fig. 5.

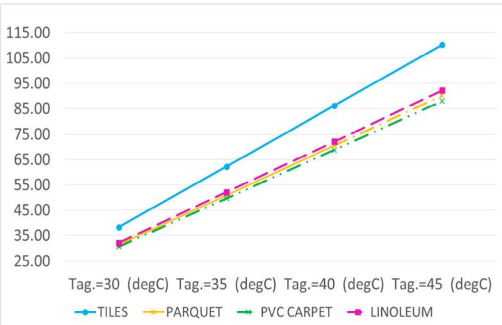

Fig. 5. *The heat distribution heat flow on the upper face of TABS*

4. Laboratory Research

4.1. Experimental conditions

To study the influence of surface coating and temperature on thermal performance of TABS a series of experimental measurements were conducted on the TABS existing surfaces in the. Faculty Building fig. 6. The radiating surface is divided into four zones with different layers of coating on the radiating surface (tiles, parquet, carpet and PVC carpet).

Fig. 6. *TABS radiant surface in the faculty laboratory*

The TABS in the laboratory has an area of 6 m^2 having a pipe coil made of PEXA 20×2,2 mm diameter and 28 m length.

The laying pipe is in the form of double coil assembly having a 20 cm mounting pitch.

The concrete slab that containes the pipe has a thickness of 20 cm and the following thermotehnic properties

$$\lambda = 2{,}00\ {}^{W}\!/_{m^2 \cdot K},\quad \rho = 2600\ {}^{kg}\!/_{m^3}$$

The schematic of the slab is presented in figure 7.

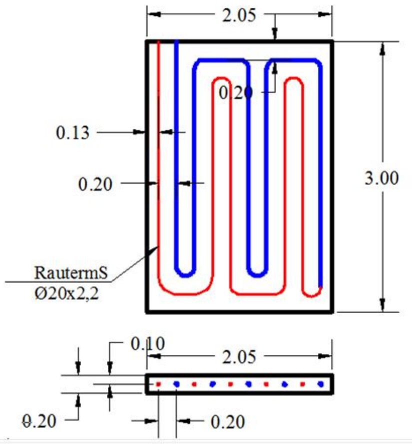

Fig. 7. *Schematics of the TABS in the radiant surface laboratory*

The thermal agent is supplied to TABS from a manifold, type HKV-D, witch also feeds the othe radiant surfaces in the laboratory [9].

The source for the thermal agent is a heat pump and an absorption chiller mounted near the faculty building of the Faculty.

Measurement and processing system for the TABS is embedded in a complex system that monitors all radiant surfaces and also the entire laboratory envelope.

4.2. Results

Measurement process results highlighted the influence of two important parameters (water temperature and radiant surface coating) on the functional performance of TABS

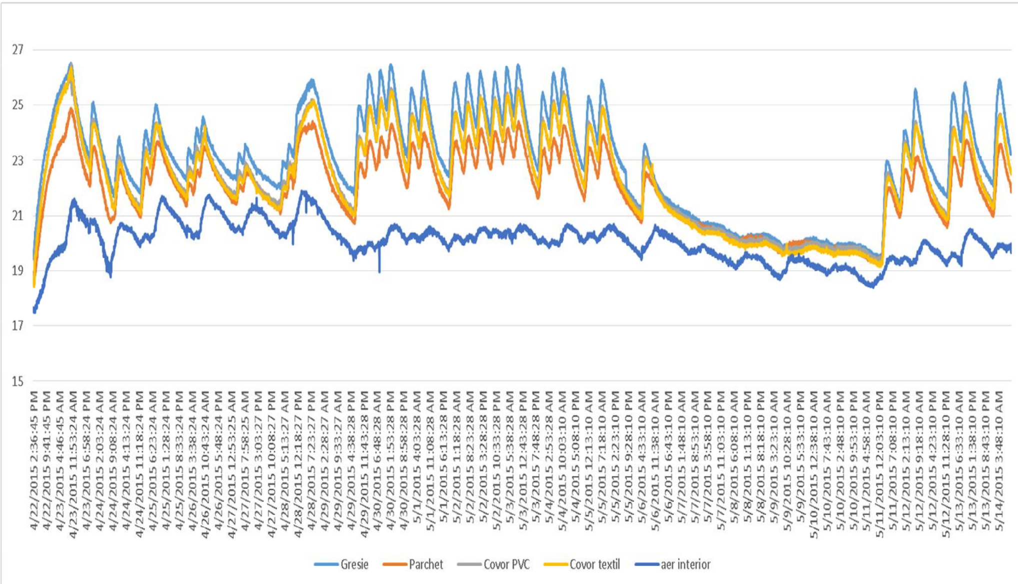

Fig. 8. *Temperature on the radiant surface*

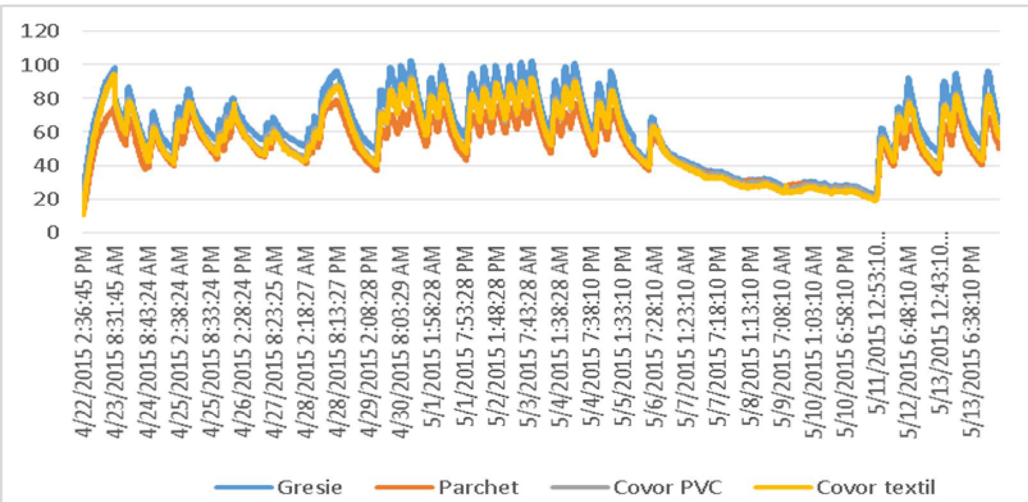

Fig. 9. *Heat flux delivered by the radiant surface*

Another important parameter is the heat flow from radiating surface. It varies depending on water temperature and the indoor air between 20 and 100 W/m^2, with lower values for the case using radial surfaces covered with woven carpets, PVC carpet and parquet.

5. Conclusion

TABS represent solutions for thermal comfort in buildings which have the capacity to provide heat for well insulated buildings.

The heat flow for TABS sites can reach values of up to 100-110 W/m^2 for heat temperatures of up to 45ºC.

Radiant surface temperature and heat flux delivered to TABS is less influenced when using parquet, PVC carpet and significantly influenced by woven carpet.

The flow temperature is the design parameters that most influence the surface temperature and heat flux system delivered to TABS.

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